DRAFT

Data Gaps Report

Newark Bay Study Area

Remedial Investigation

Tierra Solutions, Inc.

East Brunswick, New Jersey

March 2013

Revision 0

Table of Contents

Table

Figures

Acronyms and Abbreviations

AOC	Administrative Order on Consent
Be-7	Beryllium-7
bss	below sediment surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemical of potential concern
DEAR	Phase I and Phase II Data Evaluation and Assessment Report (Tierra 2013)
Deposition Report	Phase I and Phase II Sediment Deposition Report (Tierra 2011)
DQO	data quality objective
ft	foot/feet
NBSA	Newark Bay Study Area
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
PQO	project quality objective
RI	Remedial Investigation
RIWP	Remedial Investigation Work Plan
RPD	relative percent difference
SI	Sediment Investigation
SOW	Statement of Work
Tierra	Tierra Solutions, Inc.

TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1. Introduction

This Data Gaps Report has been prepared by Tierra Solutions, Inc. (Tierra), on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]), under the Newark Bay Study Area (NBSA) Administrative Order on Consent (AOC), entered pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Index No. 02-2004-2010 (U.S. Environmental Protection Agency [USEPA] 2004).

As part of the AOC, three Remedial Investigation (RI) Goals were established for the NBSA. These RI goals are:

1. *Nature and Extent of Sediment Contamination (RI Goal 1)*: Determine the horizontal and vertical distribution and concentrations of polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, and metals for the NBSA sediments (NBSA AOC Statement of Work [SOW], Section A.1).

2. *Risk Assessment (RI Goal 2)*: Determine the primary human and ecological receptors (endpoints) of PCDD-, PCDF-, PCB-, PAH-, pesticide-, and metals-contaminated sediments in the NBSA (NBSA AOC SOW, Section A.2).

3. *Source Identification (RI Goal 3)*: Determine the significant direct and indirect continuing sources of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals to the sediments in the NBSA (NBSA AOC SOW, Section A.3).

Due to the complexity of the NBSA (shown on Figure 1-1), USEPA and Tierra agreed that the RI would be implemented in multiple phases, as necessary. As such, sediment samples were collected in two phases during 2005 and 2007. Results from these Phase I and Phase II Sediment Investigations (SIs) are documented in the Phase I and Phase II Field and Data Report (Tierra 2008). Radiochemical data were evaluated with respect to the 1940 horizon and are presented in the Phase I and Phase II Sediment Deposition Report (Deposition Report; Tierra 2011). Analytical data evaluated with respect to characterization of nature and extent are presented in the Phase I and Phase II Data Evaluation and Assessment Report (DEAR; Tierra 2013). The DEAR uses the Phase I and Phase II data, in addition to sediment data from secondary sources (data collected for purposes other than the NBSA SI Program), to broadly

characterize the distribution of contamination within the NBSA with respect to RI Goal 1.

In addition to the chemicals evaluated in Phase I and Phase II, there are additional chemicals that may be present in the NBSA, including (but not limited to) emerging contaminants associated with pharmaceuticals, personal care products, and flame retardants. Some of these emerging chemicals have already been identified in the NBSA. In conjunction with Phase II activities, polychlorinated naphthalenes and polybrominated diphenyl ethers were found to be present in sediment throughout the NBSA (Tierra 2010). Because these chemicals may pose risks to both human and ecological receptors, some sampling, analysis and evaluation of these compounds will be conducted as part of the risk assessment process for the NBSA.

This Data Gaps Report was prepared to evaluate and confirm that the requirements of RI Goal 1 have been met and, if not, identify what data needs remain. Data collection pertaining to RI Goals 2 and 3 is not yet complete and, therefore, a data gaps analysis for those goals will not be discussed as part of this report.

2. Phase I and Phase II SI History

The Phase I SI was conducted in 2005 in accordance with the USEPA-approved Phase I Remedial Investigation Work Plan (Phase I RIWP; Tierra 2005). The Phase I RIWP established five data quality objectives (DQOs) to address RI Goal 1:

- DQO 1 – "Confirm the presence and extent of individual geomorphic areas."
- DQO 2 – "Estimate the approximate depth of the 1940 sediment horizon in the various geomorphic areas."
- DQO 3 – "Better understand broad constituent patterns in both the surface and subsurface sediments, and attempt to preliminarily identify "hot spots" through statistical analyses (e.g., Rosner's test [USEPA 2006])."
- DQO 4 – "Confirm that the current analytical suite is appropriate for the various geomorphic areas."
- DQO 5 – "Determine data needs for Phase II."

Upon review of the Phase I data, it was concluded that four of the five DQOs had successfully been met; however, the 1940 vertical sediment horizon was not consistently reached (DQO 2). To address this data gap, as well as other sampling objectives, a Phase II RIWP was developed (Tierra 2007). Three project quality objectives (PQOs) for Phase II were developed and presented in the Phase II RIWP (Tierra 2007) to address RI Goal 1:

- PQO 1 – "Characterize sediments to the 1940 horizon in select areas found to be accreting sediments at a relatively high rate, including select Phase I locations and other areas of potential high net deposition, as identified by the 2006 U.S. Army Corps of Engineers (USACE) Geomorphology Report (USACE 2006)."

- PQO 2 – "Characterize sediments, both surface and at depth, to further the understanding of broad spatial patterns in chemicals of potential concern (COPC) distribution in the channels and other geomorphic areas."

- PQO 3 – "Seek to understand matrix heterogeneity in select regions of the Bay."

The Phase II RIWP (Tierra 2007) and associated PQOs to meet RI Goal 1 were approved by the USEPA on October 18, 2007 and the Phase II SI was conducted in 2007. Results from the Phase I and Phase II SIs have been presented in three reports:

- 2008 Field and Data Report – This report presents field activities of the SI Programs, analytical methods, and data results (Tierra 2008).

- 2011 Sediment Deposition Report – This report presents radiochemical data to verify that sediment core penetration was sufficient to characterize sediments to the 1940 horizon depth (Tierra 2011).

- 2013 DEAR – This report presents the data analyses and subsequent evaluations performed on the Phase I, Phase II, and secondary data sets. These evaluations were conducted as a means to broadly characterize the horizontal and vertical distribution of chemical concentrations in NBSA sediments (Tierra 2013).

3. Evaluation of Data Gaps

As previously stated, the main objective of this report is to assess whether the NBSA has been adequately characterized with respect to RI Goal 1 – nature and extent of sediment contamination. To complete this evaluation, each Phase I DQO and Phase II

PQO related to RI Goal 1 was reviewed using lines of evidence from data evaluations completed to date (e.g., the Deposition Report and the DEAR; Tierra 2011, 2013, respectively).

As noted in the DEAR (Tierra 2013), secondary data collected between 2000 and the present[1] support the conclusions drawn from the data collected during Phase I and Phase II. Consequently, secondary data are not extensively discussed in this report, and evidence as to whether a DQO or PQO was addressed is primarily based on Phase I and Phase II data. Information about how Phase I, Phase II, and secondary data were utilized with respect to RI Goal 1 can be found in the DEAR. For reference, Phase I, Phase II, and secondary data locations within the NBSA and discussed in the DEAR are presented on Figures 3-1a and 3-1b.

Table 3-1 presents each DQO and PQO and provides a summary of how each specific objective was achieved.

3.1 Phase I DQO 1

Confirm the presence and extent of individual geomorphic areas.

The Phase I RIWP preliminarily identified and evaluated the extent of seven geomorphic areas within the NBSA based on water depth, shoreline modifications, and areas affected by dredging and filling (Tierra 2005). A bathymetric survey of the NBSA was conducted as part of the Phase I SI, and the results of this survey, in conjunction with information from the 2006 USACE Geomorphology Report (USACE 2006), were used to further understand geomorphology within the NBSA. The geomorphic areas were refined based on differences in bathymetry, natural (e.g., mudflats or wetlands) and man-made (e.g., navigation channels) geomorphological features, water depth, and hydrodynamics within the NBSA (Figure 3-2). These refined geomorphic areas are identified in the USEPA-approved Deposition Report (Tierra 2011) and include: Industrial Waterfront Areas, Subtidal Flats, Historically Disturbed Subtidal Flats, Intertidal Areas, Transitional Slopes, Port Channels, and Navigation Channels.

[1] This timeframe is comparable to that of the Phase I/Phase II dataset and more indicative of current conditions.

Geomorphic areas within the NBSA can be differentiated based on physical and/or chemical processes, such as dredging, sedimentation, hydrodynamics, and direct chemical inputs resulting from local sources.

To evaluate chemical differences between geomorphic areas, statistical analyses and graphical comparisons were conducted to identify statistically significant differences in chemical concentrations within the seven geomorphic areas of the NBSA. Statistically significant differences in chemical concentrations between a geomorphic area and the rest of the NBSA can be used as one line of evidence to define the presence and extent of the geomorphic area. The statistical analyses were conducted for the 18 chemicals selected for focused evaluation[2] as part of the DEAR (Tierra 2013) (hereafter referred to as the 18 select chemicals). The results of those evaluations determined chemical concentrations were statistically significantly lower in Subtidal Flats (compared to the overall mean for the NBSA) for 13 of the 18 select chemicals in mid-depth sediments (0.5 to 3.5 feet below sediment surface [ft bss]), and all 18 of the select chemicals for subsurface sediments. Additionally, statistically significantly higher chemical concentrations (compared to the overall mean for the NBSA) were generally observed in Historically Disturbed Subtidal Flats and Industrial Waterfront Areas. These areas are expected to have differing chemical concentrations, which can be attributed to low energy patterns (e.g., Subtidal Flats, and Historically Disturbed Subtidal Flats) and proximity to localized sources of contaminants (e.g., Industrial Waterfront Areas).

For the remaining geomorphic areas (Navigation Channels, Port Channels, Transitional Slopes, and Intertidal Areas), there were few statistically significant differences identified, however this is expected based on the physical characteristics of these areas. Navigation Channels, Port Channels, Transitional Slopes, and Intertidal Areas are considered high energy areas and are more frequently disturbed. The Navigation Channels and Port Channels have been dredged to allow for deep-draft ship traffic, which has also impacted (and created) the Transitional Slopes. Finally, Intertidal Areas, although a small portion of the NBSA, are a separate geomorphic area as it is the region of Newark Bay that is exposed to constantly changing tides. These

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[2] The 18 select chemicals are: 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, Total Aroclor PCBs, Total Congener PCBs, Total Alpha + Gamma Chlordane, Total dichlorodiphenyl-trichloroethane (4,4'), bis(2-ethylhexyl)phthalate, Total PAHs, and TPH.

high energy locations experience patterns of disturbance, which may inhibit observations of statistically significant differences of chemical concentrations.

Geomorphic areas were identified based on lines of evidence described above, and in areas where chemical differences would be expected (Subtidal Flats, Historically Disturbed Subtidal Flats, and Industrial Waterfront Areas), the evaluations conducted as part of the DEAR (Tierra 2013) show statistically significant differences in chemical concentrations. For the remaining geomorphic areas (Navigation Channels, Port Channels, Transitional Slopes, and Intertidal Areas) physical characteristics are the defining feature of these areas, and although statistically significant differences were not generally observed, this is expected. This information supports the conclusion that individual geomorphic areas have been identified and adequately characterized as presented in the Deposition Report (Tierra 2011). Therefore, this DQO has been addressed, and there are no data gaps related to this objective.

3.2 Phase I DQO 2 and Phase II PQO 1

Phase I DQO 2: Estimate the approximate depth of the 1940 sediment horizon in the various geomorphic areas.

Phase II PQO 1: Characterize sediments to the 1940 horizon depth in select areas found to be accreting sediments at a relatively high rate, including select Phase I locations and other areas of potential high net deposition, as identified by the 2006 USACE Geomorphology Report (USACE 2006).

Although there were many cores collected during the Phase I SI that were estimated to have reached the 1940 horizon, it was determined that some of the cores did not extend deep enough. As later confirmed through a review of the Geomorphology Report prepared by the USACE (USACE 2006), many of the Phase I sediment cores were located in, or adjacent to, areas potentially impacted by historical anthropogenic activities. In essence, the 1940 horizon in these areas appeared to be deeper in the sediment column than originally thought (Tierra 2007). Consequently, Tierra returned to those locations during Phase II to collect sediment deep enough to allow characterization of sediments down to the depth of the 1940 horizon.

The Phase I and Phase II cores were evaluated with respect to the 1940 horizon, and cores were determined to have reached the depth of the 1940 horizon based on multiple lines of evidence including radiochemical markers, lithology, bathymetry, and select chemical markers, as presented in the Deposition Report (Tierra 2011). Forty-

two cores were collected during the Phase I SI that captured or surpassed the 1940 horizon, and 18 cores collected during Phase II captured or surpassed the 1940 horizon (Tierra 2011). Of the 60 cores that captured or surpassed the 1940 horizon, 21 were collected from USACE areas of potential high net deposition (referred to herein as "sediment accumulation areas;" Figure 3-3), and each geomorphic area had at least three cores that captured the depth of the 1940 horizon.

Based on the summation of this information, Phase I DQO 2 and Phase II PQO 1 have been addressed, and there are no data gaps related to these objectives.

3.3 Phase I DQO 3 and Phase II PQO 2

Phase I DQO 3: Better understand broad constituent patterns in both the surface and subsurface sediments, and attempt to preliminarily identify 'hot spots' through statistical analyses (e.g. Rosner's test).

Phase II PQO 2: Characterize sediments, both surface and at depth, to further the understanding of broad spatial patterns in COPC distribution in the channels and other geomorphic areas.

Phase I and Phase II sediment analytical data, in addition to secondary data, were evaluated with respect to geographic areas, geomorphic areas, the navigation channels, USACE sediment accumulation areas (an indicator of historical deposition), and the presence of beryllium-7 (Be-7; an indicator of recent sediment deposition). Data were also evaluated in three vertical categories: surface (0 to 0.5 ft bss), mid-depth (0.5 to 3.5 ft bss), and subsurface (greater than 3.5 ft bss). These data were evaluated using various statistical analyses and graphical visualizations, and broad spatial patterns were identified and discussed in the DEAR (Tierra 2013).

The DEAR (Tierra 2013) identified locations of statistically higher chemical concentrations in a point-by-point approach (Dixon's Extreme Value Test for sample sizes less than or equal to 25 and Rosner's test for sample sizes greater than 25) and by area characterization (multiple comparison tests). Furthermore, sediment data for the 18 select chemicals were normalized to total organic carbon and aluminum and were evaluated to assess the influence of natural variability on the observed chemical distributions.

In general, locations of statistically higher chemical concentrations, as compared to the overall mean for the NBSA, were found in Newark Bay South, in sediments west of the

navigation channel and in USACE accumulation areas. Locations of statistically lower chemical concentrations were identified in Newark Bay North and east of the navigation channel. Geomorphic areas were also evaluated and locations of statistically higher chemical concentrations, as compared to the overall mean for the NBSA, were found in the Historically Disturbed Subtidal Flats and Industrial Waterfront Areas, with locations of statistically lower chemical concentrations identified in the Subtidal Flats. For all depth intervals, normalizing the data showed that the natural variability in sediment characteristics is not the dominating factor in observed concentrations for the select 18 chemicals evaluated in the DEAR (Tierra 2013).

Through these evaluations, surface and subsurface sediments have been determined to be characterized sufficiently to support development of an understanding of broad spatial COPC patterns in the NBSA. Further, statistical analyses have been conducted to preliminarily identify 'hot spots.' Therefore, Phase I DQO 3 and Phase II PQO 2 have been met, and there are no data gaps related to these objectives.

3.4 Phase I DQO 4

Confirm that the current analytical suite is appropriate for the various geomorphic areas.

As specified in the USEPA-approved Phase I RIWP (Tierra 2005), sediment samples collected during the Phase I SI were analyzed for 461 individual chemicals or chemical groups, and concentrations were calculated for an additional 10 chemical groups. This list was developed in concurrence with USEPA based on secondary data and the history of industrialization and likely discharges to the NBSA. The list includes inorganics, volatile organic compounds (VOCs), semivolatile organic compounds, PAHs, pesticides, herbicides, Aroclor PCBs, Congener PCBs, PCDDs/PCDFs, organotins, total petroleum hydrocarbons (TPH), and cyanide, which covers the range of USEPA-approved chemicals for analysis in NBSA sediments.

During the evaluation of Phase I SI data, results showed VOCs had limited detection frequencies, and organotins had low detected concentrations. As such, organotins were omitted and only six VOCs were retained for analysis as part of the USEPA-approved Phase II SI. The list of USEPA-approved COPCs analyzed during Phase II was otherwise the same as the Phase I constituent list.

During both the Phase I and Phase II SIs, samples were collected from throughout the NBSA, including each of the geomorphic areas. Each sample was analyzed for the full

list of chemicals to allow for broad characterization of nature and extent of sediment contamination within the NBSA. Evaluations conducted as part of the Deposition Report (Tierra 2011) and DEAR (Tierra 2013) considered each of the 461 individual chemicals or chemical group results, however, as described in the DEAR, 18 chemicals were selected for focused statistical and visual evaluations. The 18 select chemicals were chosen based on regional concerns regarding NBSA sediments, frequency of detection, presence of statistical outliers, or ability to facilitate broad characterization of chemical distribution in NBSA sediments (e.g., calculated total concentrations for PAH, PCB, and DDT chemical compounds). These 18 select chemicals comprise nearly 70 percent of the individual chemicals or chemical groups detected in Newark Bay sediments during both SIs. Additionally, these 18 select chemicals were consistently measured above ecological screening values, as shown in Table 4-3 of the DEAR. The remaining chemicals not selected for focused evaluation generally showed low detection frequencies (less than 50 percent) and were therefore excluded from focused evaluation.

This dataset, combined with the analysis and evaluation conducted as part of the DEAR (Tierra 2013), supports the conclusion that the analytical suite from the combined Phase I and Phase II SIs is appropriate for each of the seven geomorphic areas and three vertical categories. As such, this DQO has been addressed, and there are no data gaps related to this objective.

3.5 Phase I DQO 5

Determine data needs for Phase II.

Upon completion of the Phase I SI, the data were evaluated, and, in conjunction with USEPA, data needs for the Phase II SI were identified. These data needs are presented in the USEPA-approved Phase II RIWP (Tierra 2007). As such, this DQO has been addressed, and there are no data gaps related to this objective.

3.6 Phase II PQO 3

Seek to understand matrix heterogeneity in select regions of the Bay.

Matrix heterogeneity was investigated in select regions of the Bay through evaluation of co-located and nearby cores. Twenty-five Phase I sediment sample locations distributed throughout the NBSA were re-sampled during the Phase II SI Program (co-located cores; including sediment cores and surface sediment samples) to enhance

the understanding of near-field sediment heterogeneity in the NBSA. This evaluation was conducted by comparing chemical concentrations in surface samples at those paired locations. As a measure of comparability, the relative percent difference (RPD) of analytical results for each of the paired surface sample results was calculated and presented in the DEAR (Tierra 2013). In addition to the co-located cores, concentrations in nearby cores (either Phase I or Phase II cores, or cores collected from secondary evaluations) were evaluated to assess matrix heterogeneity on a comparatively larger scale. Results from nearby cores were qualitatively evaluated. Based on these evaluations and as stated in the DEAR, heterogeneity in chemical concentrations appears to be greater over larger distances (e.g., between geographic areas) compared to smaller distances (e.g., between co-located cores). Matrix heterogeneity in select regions of the Bay was investigated within the NBSA based on the RPD evaluation of co-located cores and the evaluation of nearby cores. The data generated provided sufficient information to understand matrix heterogeneity within the NBSA; therefore this PQO has been addressed, and there are no data gaps related to this objective.

4. Conclusions

Based on the lines of evidence presented in this report, the Phase I DQOs and Phase II PQOs have been met.

- Phase I DQO 1 – confirm the presence and extent of individual geomorphic areas.

  Geomorphic areas were defined in the Phase II RIWP, and refined using the 2005 bathymetric survey and the USACE 2006 Geomorphology Report. Based on this information, seven geomorphic areas were defined in the Deposition Report (Tierra 2011), and statistical evaluations conducted as part of the DEAR (Tierra 2013) confirm differences in chemical concentrations between these areas.

- Phase I DQO2 and Phase II PQO 1 – depth of the 1940 sediment horizon.

  Based on multiple lines of evidence, including radiochemical markers, lithology, bathymetry, and chemical markers, it was determined that the 1940 horizon was captured or surpassed in 60 cores from the seven geomorphic areas (with at least three cores from each geomorphic area). Additionally, 21 cores in USACE sediment accumulation areas also captured or surpassed the 1940 horizon, demonstrating sediments were adequately characterized to 1940.

- Phase I DQO 3 and Phase II PQO 2 – characterize broad COPC patterns in surface and subsurface sediments.

  Surface and subsurface sediments were characterized with respect to a broad range of COPCs, which were evaluated with respect to geographic, geomorphic, proximity to the navigation channel (i.e., east or west of the navigation channel) and USACE accumulation areas, as well as by depth interval (surface, mid-depth, and subsurface). In addition, surface data were also evaluated relative to recent deposition (Be-7 activity) and bay mile location.

- Phase I DQO 4 – confirm that the current analytical suite is appropriate for the various geomorphic areas.

  The analytical suite used during the Phase I SI was developed in conjunction with the USEPA and included 461 individual chemicals or chemical groups, and concentrations were calculated for an additional 10 chemical groups. For the Phase II SI, this list was reduced based on limited detection frequencies and low detected concentrations for a subset of chemicals. As such, the analytical suite is appropriate for each geomorphic area within the NBSA.

- Phase I DQO 5 – determine data needs for Phase II.

  Upon completion of the Phase I SI, the data were evaluated, and, in conjunction with USEPA, data needs for the Phase II SI were identified. These data needs are presented in the USEPA-approved Phase II RIWP (Tierra 2007). As such, this DQO has been addressed, and there are no data gaps related to this objective.

- Phase II PQO 3 – seek to understand matrix heterogeneity in select regions of the Bay.

  Matrix heterogeneity in select regions of the Bay has been investigated within the NBSA based on the RPD evaluation of co-located cores and a qualitative evaluation of nearby cores. The data generated provided sufficient information to understand matrix heterogeneity within the NBSA.

As each of the Phase I DQOs and Phase II PQOs has been addressed, Phase I and Phase II of the RI are complete. No further data are needed to satisfy the intent of RI Goal 1 at this time. In support of any additional data use objectives, the data will need to be re-evaluated with those objectives in mind.

5. References

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Table

Table 3-1
Summary of Phase I DQOs and Phase II PQOs

DQO or PQO		How Objective Was Met
Phase I DQO 1	Confirm the presence and extent of individual geomorphic areas.	The DEAR (Tierra 2013) demonstrates that seven geomorphic areas were identified and defined using bathymetry (including findings from the USACE Geomorphology Report; USACE 2006), geomorphology, water depth, and hydrodynamics. These differences are further confirmed through statistically significant differences in chemical concentrations for each geomorphic area compared to the overall mean for the NBSA. As such, this DQO has been met, and there are no data gaps related to this objective.
Phase I DQO 2 and Phase II PQO 1	DQO 2: Estimate the approximate depth of the 1940 sediment horizon in the various geomorphic areas. PQO 1: Characterize sediments to the 1940 horizon in select areas found to be accreting sediments at a relatively high rate, including select Phase I locations and other areas of potential high net deposition, as identified by the 2006 USACE Geomorphology Report.	The Phase I and Phase II Sediment Deposition Report (Tierra 2011) and the DEAR demonstrate that the 1940 horizon was captured or surpassed in all geomorphic areas and in USACE sediment accumulation areas (USACE 2006) based on multiple lines of evidence, including radiochemical markers, lithology, bathymetry, and select chemical markers: • 60 cores in the 7 geomorphic areas (with at least 3 cores per area) were characterized to a depth capturing or surpassing the 1940 horizon. • 21 cores collected in USACE sediment accumulation areas were characterized to a depth capturing or surpassing the 1940 horizon depth. As such, Phase I DQO 2 and Phase II PQO 1 have been met, and there are no data gaps related to these objectives.
Phase I DQO 3 and Phase II PQO 2	DQO 3: Better understand broad patterns of constituents in both the surface and subsurface sediments, and attempt to preliminarily identify 'hot spots' through statistical analyses (e.g., Rosner's test). PQO 2: Characterize sediments, both surface and at depth, to further the understanding of broad spatial patterns in COPC distribution in the channels and other geomorphic areas.	Section 4 of the DEAR describes the statistical analyses performed, including Rosner's test. The DEAR identifies locations of statistically higher chemical concentrations in a point-by-point approach (statistical outliers) and by area characterization (multiple comparison tests). Broad spatial patterns of constituents based on geographic, geomorphic, navigation channel, and USACE sediment accumulation areas are described in the DEAR. In addition, surface data were evaluated relative to recent deposition (Be-7 activity) and bay mile location in the DEAR. COPCs in each area were characterized vertically based on three depth intervals (0 to 0.5 ft bss, 0.5 to 3.5 ft bss, and greater than 3.5 ft bss). Broad spatial

Table 3-1
Summary of Phase I DQOs and Phase II PQOs

DQO or PQO		How Objective Was Met
		patterns of chemicals and statistically significant differences in chemical concentrations compared to the overall mean for the NBSA based on these horizontal and vertical categories were observed and are discussed in Section 5 of the DEAR. As such, Phase I DQO 3 and Phase II PQO 2 have been met, and there are no data gaps related to these objectives.
Phase I DQO 4	Confirm that the current analytical suite is appropriate for the various geomorphic areas.	The analytical suite used during the Phase I SI was developed in conjunction with USEPA and included 461 individual chemicals or chemical groups, and concentrations were calculated for an additional 10 chemical groups. For the Phase II SI, this list was reduced based on limited detection frequencies and low detected concentrations for a subset of chemicals. This list was further reduced to 18 chemicals for the DEAR, representing 70% of the detected chemicals during both SIs, and chemicals that were consistently measured above ecological screening values. Based on this information, this DQO has been addressed, and there are no data gaps related to this objective.
Phase I DQO 5	Determine data needs for Phase II.	Upon completion of the Phase I SI, the data were evaluated, and in conjunction with USEPA, data needs for the Phase II SI were identified. These data needs are presented in the USEPA-approved Phase II Remedial Investigation Work Plan (Tierra 2007). As such, this DQO has been addressed, and there are no data gaps related to this objective.
Phase II PQO 3	Seek to understand matrix heterogeneity in select regions of the Bay.	Matrix heterogeneity was investigated through the evaluation of co-located and nearby cores, as described in the DEAR. Heterogeneity in chemical concentrations was shown to usually be greater over larger distances (nearby cores) compared to smaller distances (co-located cores). As such, this PQO has been addressed, and there are no data gaps related to this objective.

Table 3-1
Summary of Phase I DQOs and Phase II PQOs

Note:

1. The 18 select chemicals are: 2,3,7,8- tetrachlorodibenzo-*p*-dioxin, arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, Total Aroclor PCBs, Total Congener PCBs, Total Alpha + Gamma Chlordane, Total dichlorodiphenyl-trichloroethane (4,4'), bis(2-ethylhexyl)phthalate, Total polycyclic aromatic hydrocarbons, and total petroleum hydrocarbons.

Acronyms and Abbreviations:

Be-7 = beryllium-7
COPC = chemical of potential concern
DEAR = Phase I and Phase II Data Evaluation and Analysis Report
DQO = data quality objective
ft bss = feet below sediment surface
PCB = polychlorinated biphenyl
PQO = project quality objective
SI = sediment investigation
USACE = U.S. Army Corps of Engineers
USEPA = U.S. Environmental Protection Agency
VOC = volatile organic compound

Figures

DRAFT

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: kives
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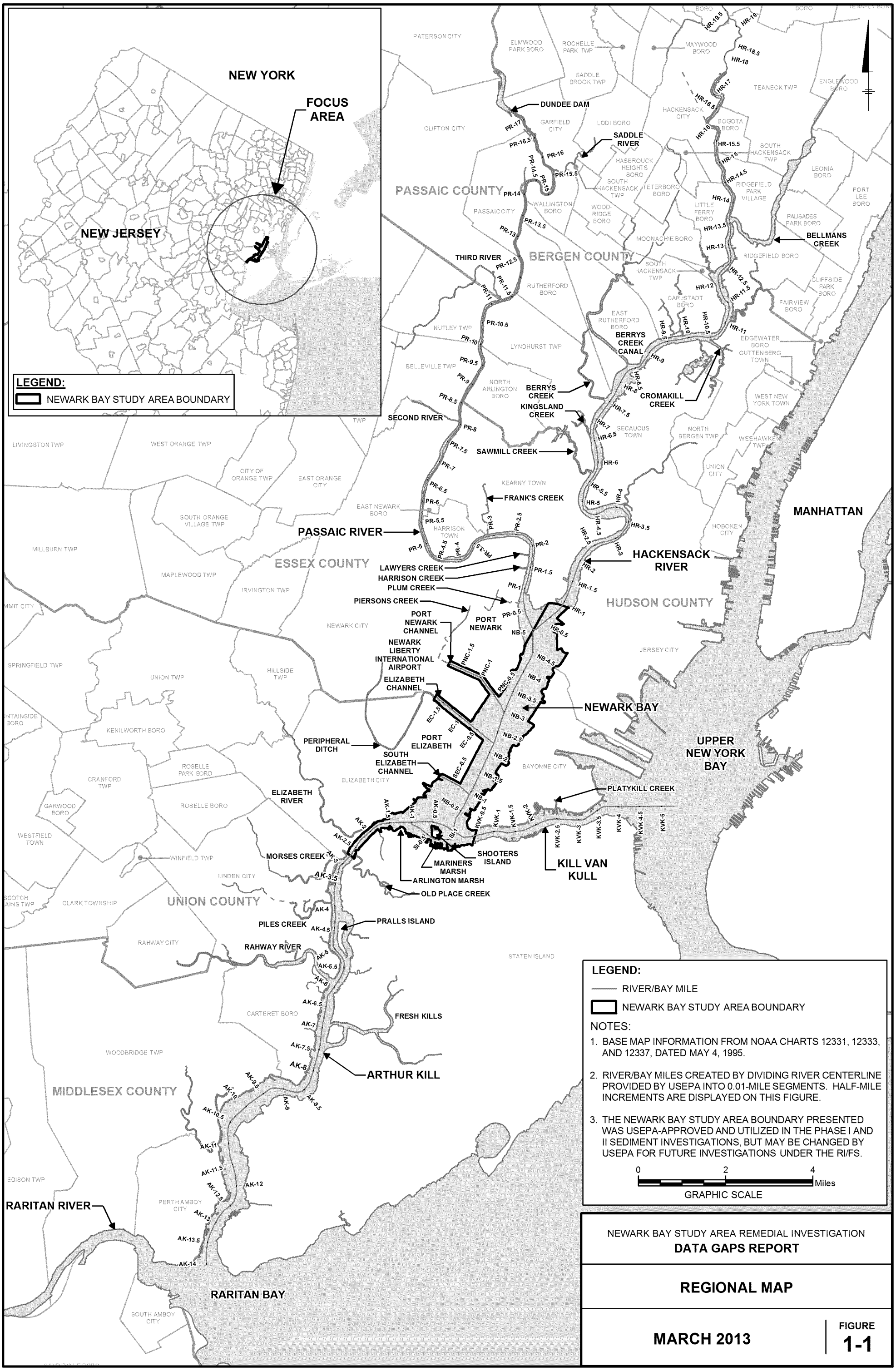


NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION
DATA GAPS REPORT

REGIONAL MAP

MARCH 2013

FIGURE 1-1

FOIA_07123_0003633_0022

DRAFT

City: Syracuse Div/Group: Created By: B deClercq Last Saved By: kives
Project (B0009989.0020.00001)
W:\GIS\Task\NBSA\DataGapReport\mxd\SedimentSample Locations – Location IDs.mxd 3/29/2013 11:38:24 AM

LEGEND:

NEWARK BAY PHASE I AND PHASE II SEDIMENT INVESTIGATIONS

- PHASE I SEDIMENT CORE LOCATION
- PHASE II SEDIMENT CORE LOCATION
- CO-LOCATED SEDIMENT CORE LOCATION

ADDITIONAL DATASETS BY SAMPLING EVENT:

LEVEL 2 DATASETS (YELLOW SYMBOLS)

- 1998 TO 2001 CARP SEDIMENT PROGRAM - HRT
- 1998 TO 2001 CARP SEDIMENT PROGRAM - HRA
- 2008 USACE STRATIFIED SAMPLING PROJECT

LEVEL 3 DATASET (PURPLE SYMBOLS)

- 1999 TO 2006 HONEYWELL SEDIMENT INVESTIGATIONS
- SHORELINE
- UNDERGROUND TRIBUTARY
- NBSA
- 2-MILE EXTENDED AREAS

PASSAIC RIVER
HACKENSACK RIVER
CONRAIL BRIDGE REMNANTS
CONRAIL BRIDGE REMNANTS
SEE FIGURE 3-1b
PIERSONS CREEK
PORT NEWARK CHANNEL
ELIZABETH CHANNEL
NEWARK LIBERTY INTERNATIONAL AIRPORT
NEWARK BAY CDF (CELL 1S)
PERIPHERAL DITCH
SOUTH ELIZABETH CHANNEL
ELIZABETH RIVER
KILL VAN KULL
BAYONNE BRIDGE
MORSES CREEK
GOETHALS BRIDGE
SHOOTERS ISLAND
ARTHUR KILL
PILES CREEK
PRALLS ISLAND
STATEN ISLAND

SD003-RF3, SD001-RF3, SD002-RF3, 001A, 002, 003, 004, 005, 006A, 007, 008A, 009, 010A, 011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 030, 031, 032, 033A, 034A, 035A, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 051, 052, 053, 054, 055, 056, 057, 058, 059, 060, 061, 062, 063, 064, 065, 066, 068, 070, 071, 072, 074, 075, 076, 077, 078, 079, 080, 082, 088, 089, 090, 091, 092, 093, 094, 097, 098, 101, 102, 103, 104, 105, 106, 107, 109, 110, 111, 112, 113, 114, 115, 116, 118, 119, 120, NB901, NBA06, NWB01, NWB01A, VT-08-01, VT-08-02, VT-08-03, VT-08-04, VT-08-05, VT-08-06, VT-08-07, VT-08-08, VT-08-09, VT-08-10, VT-08-11, VT-08-12, VT-08-13, VT-08-14, VT-08-15, VT-08-16, VT-08-17, VT-08-18, VT-08-19, VT-08-20, VT-08-21, VT-08-22, TS6-SD-100, TS6-SD-050, TS6-SD-025, TS6-SD-005, TS7-SD-025, TS7-SD-005, TS7-SD-050, TS7-SD-100, TS8-SD-100, TS8-SD-050, TS8-SD-025, TS8-SD-005, TS9-SD-100, TS9-SD-050, TS9-SD-025, TS9-SD-005, TS10-SD-100, TS10-SD-050, TS10-SD-025, TS10-SD-005, TS11-SD-100, TS11-SD-050, TS11-SD-025, TS11-SD-005, TS12-SD-005, TS12-SD-050, TS12-SD-100, TS12-SD-025

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. DATA USABILITY LEVELS ARE INDICATED IN THE LEGEND FOR EACH DATASET. FOR INFORMATION ABOUT THE DATA USABILITY LEVELS AND THEIR APPLICABILITY, PLEASE REFER TO SECTION 3 OF THE PHASE I AND PHASE II DATA EVALUATION AND ANALYSIS REPORT.
4. FOR PRESENTATION PURPOSES, THE NEWARK BAY PHASE I AND PHASE II LOCATION IDS WERE SHORTENED TO THE LAST THREE CHARACTERS OF THE LOCATION ID. FOR EXAMPLE, NB01SED026 WAS SHORTENED TO "026."

0 0.5 1 Miles
GRAPHIC SCALE

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

DATA GAPS REPORT

NEWARK BAY SAMPLE LOCATIONS BY SAMPLING EVENT

MARCH 2013

FIGURE 3-1a

DRAFT

City: Syracuse Div/Group: Created By: B deClercq Last Saved By: kives
Project (B0009989.0020.00001)
W:\GIS\Task\NBSA\DataGapReport\mxd\SedimentSample Locations – Location IDs - Honeywell Area.mxd 3/29/2013 10:55:35 AM

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. DATA USABILITY LEVELS ARE INDICATED IN THE LEGEND FOR EACH DATASET. FOR INFORMATION ABOUT THE DATA USABILITY LEVELS AND THEIR APPLICABILITY, PLEASE REFER TO SECTION 3 OF THE PHASE I AND PHASE II DATA EVALUATION AND ANALYSIS REPORT.
3. FOR PRESENTATION PURPOSES, THE NEWARK BAY PHASE I AND PHASE II LOCATION IDS WERE SHORTENED TO THE LAST THREE CHARACTERS OF THE LOCATION ID. FOR EXAMPLE, NB01SED026 WAS SHORTENED TO "026."

0 200 400 Feet
GRAPHIC SCALE

LEGEND:

NEWARK BAY PHASE I AND PHASE II SEDIMENT INVESTIGATIONS

- PHASE I SEDIMENT CORE LOCATION
- PHASE II SEDIMENT CORE LOCATION
- CO-LOCATED SEDIMENT CORE LOCATION

ADDITIONAL DATASET BY SAMPLING EVENT:

LEVEL 3 DATASET (PURPLE SYMBOLS)

- 1999 TO 2006 HONEYWELL SEDIMENT INVESTIGATIONS
- NBSA
- 2-MILE EXTENDED AREAS

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

DATA GAPS REPORT

NEWARK BAY SAMPLE LOCATIONS BY SAMPLING EVENT HONEYWELL SAMPLE AREA

MARCH 2013

FIGURE 3-1b

DRAFT

City: Syracuse Div/Group: Created By: B deClercq Last Saved By: kives
Project (B0009989.0020.00001)
W:\GIS\Task\NBSA\DataGapReport\mxd\PhI&IISediment Sample Locations – Geomorphic Units.mxd 3/27/2013 2:17:38 PM

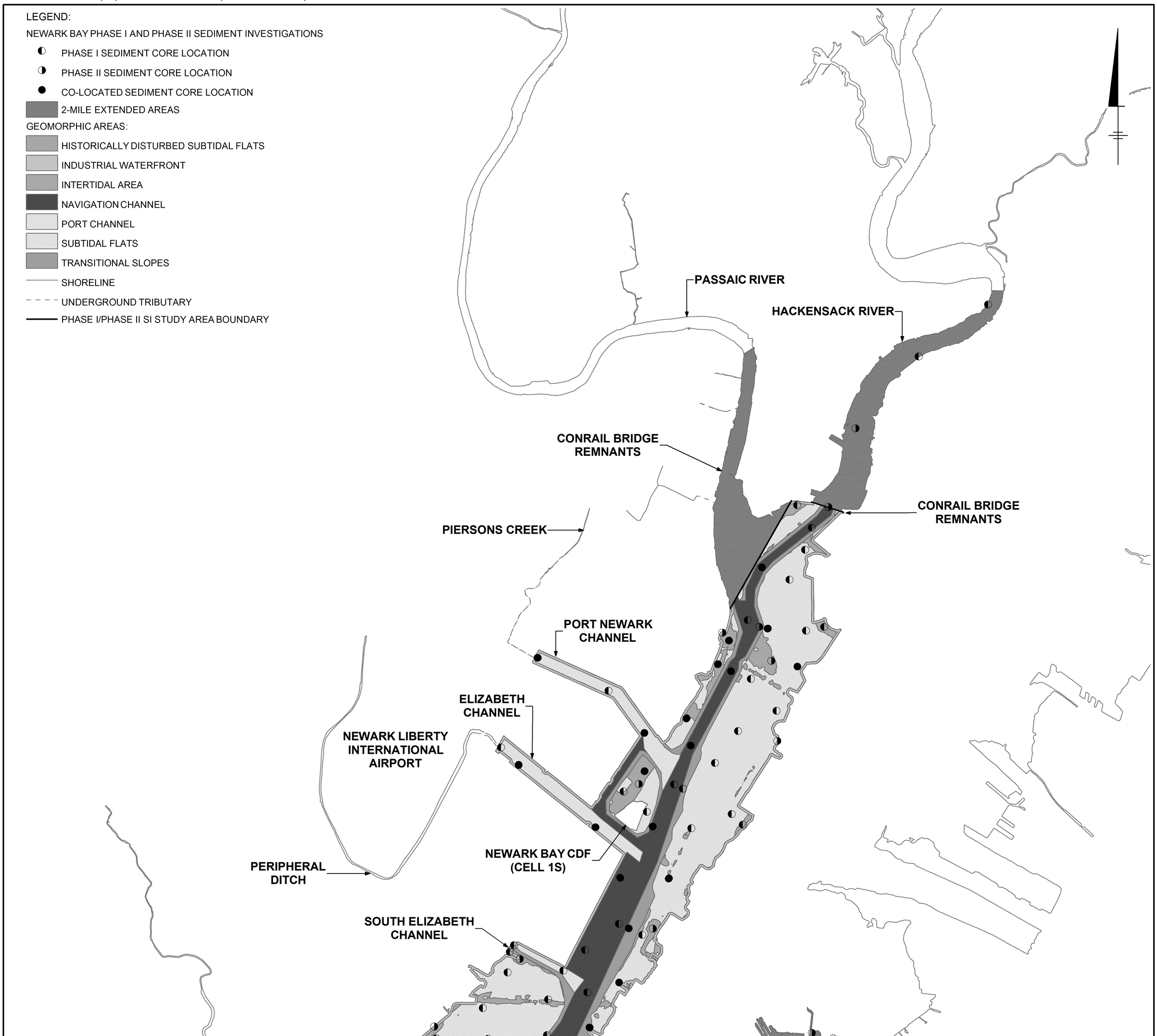
LEGEND:

NEWARK BAY PHASE I AND PHASE II SEDIMENT INVESTIGATIONS

- PHASE I SEDIMENT CORE LOCATION
- PHASE II SEDIMENT CORE LOCATION
- CO-LOCATED SEDIMENT CORE LOCATION
- 2-MILE EXTENDED AREAS

GEOMORPHIC AREAS:

- HISTORICALLY DISTURBED SUBTIDAL FLATS
- INDUSTRIAL WATERFRONT
- INTERTIDAL AREA
- NAVIGATION CHANNEL
- PORT CHANNEL
- SUBTIDAL FLATS
- TRANSITIONAL SLOPES
- SHORELINE
- UNDERGROUND TRIBUTARY
- PHASE I/PHASE II SI STUDY AREA BOUNDARY



GEOMORPHIC AREA	PHASE I SI CORES	PHASE II SI CORES	TOTAL CORES	CORES CAPTURING OR SURPASSING THE 1940 HORIZON
HISTORICALLYDISTURBEDSUBTIDALFLATS	6	10	16	11
SUBTIDALFLATS	23	5	28	20
TRANSITIONALSLOPES	7	2	9	8
INDUSTRIAL WATERFRONT AREAS	5	2	7	3
INTERTIDAL AREAS	3	0	3	3
NAVIGATION CHANNELS	17	1	18	10
PORT CHANNELS	6	1	7	5
TOTAL	**67**	**21**	**88**	**60**

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. THE GEOMORPHIC AREAS SHOWN ARE CONSISTENT WITH THOSE PRESENTED IN THE NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION PHASE I AND PHASE II SEDIMENT DEPOSITION REPORT, REVISION 1 (TIERRA 2011).

0 0.5 1 Miles
GRAPHIC SCALE

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

DATA GAPS REPORT

NEWARK BAY GEOMORPHIC AREAS

MARCH 2013

FIGURE 3-2

DRAFT

City: Syracuse Div/Group: IT Created By: K. SINSABAUGH Last Saved By: kives
Project (B0009989.0020.00005)
W:\GIS\Task\NBSA\DataGapReport\mxd\PhI&IISediment Sample Locations – Geographic Areas.mxd 3/27/2013 2:21:43 PM

LEGEND:

- NON-Be-7 BEARING LOCATION
- Be-7 BEARING LOCATION
- USACE SEDIMENT ACCUMULATION AREA
- SHORELINE
- UNDERGROUND TRIBUTARY

NEWARK BAY PHASE I AND PHASE II SEDIMENT INVESTIGATIONS

- PHASE I SEDIMENT CORE LOCATION
- PHASE II SEDIMENT CORE LOCATION
- CO-LOCATED SEDIMENT CORE LOCATION

GEOGRAPHIC AREAS:

2-MILE EXTENDED AREAS

- ARTHUR KILL
- ELIZABETH RIVER
- HACKENSACK RIVER
- KILL VAN KULL
- MORSES CREEK
- PASSAIC RIVER
- PILES CREEK

NBSA

- NEWARK BAY CENTRAL
- NEWARK BAY NORTH
- NEWARK BAY SOUTH

PASSAIC RIVER
HACKENSACK RIVER
CONRAIL BRIDGE REMNANTS
CONRAIL BRIDGE REMNANTS
PIERSONS CREEK
PORT NEWARK CHANNEL
ELIZABETH CHANNEL
NEWARK LIBERTY INTERNATIONAL AIRPORT
NEWARK BAY CDF (CELL 1S)
PERIPHERAL DITCH
SOUTH ELIZABETH CHANNEL
KILL VAN KULL
BAYONNE BRIDGE
MORSES CREEK
GOETHALS BRIDGE
ARTHUR KILL
SHOOTERS ISLAND
PILES CREEK
STATEN ISLAND
PRALLS ISLAND

NOTES:

1. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD83.
2. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
3. Be-7 BEARING LOCATIONS ARE DEFINED AS LOCATIONS WITH SURFACE SAMPLES ANALYZED FOR Be-7 AND RESULT CONCENTRATIONS GREATER THAN OR EQUAL TO 0.5 PICOCURIE PER GRAM (pCi/g). THESE LOCATIONS ARE CONSIDERED TO INDICATE RECENTLY DEPOSITED SEDIMENTS. NON-Be-7 BEARING LOCATIONS ARE LOCATIONS WITH SURFACE SAMPLES ANALYZED FOR Be-7, BUT WITH RESULT CONCENTRATIONS LESS THAN 0.5 pCi/g.
4. AT SOME CO-LOCATED LOCATIONS, ONE OF THE SURFACE SEDIMENT SAMPLES WAS Be-7 BEARING (INDICATING RECENTLY DEPOSITED SEDIMENTS), AND THE OTHER WAS NON-Be-7 BEARING. THESE LOCATIONS ARE INDICATED BY BOTH AN ORANGE TRIANGLE AND A GREEN RING.

0 0.5 1 Miles
GRAPHIC SCALE

NEWARK BAY STUDY AREA REMEDIAL INVESTIGATION

DATA GAPS REPORT

GEOGRAPHIC, USACE ACCUMULATION AREA, AND BERYLLIUM-7 BEARING REFERENCE LOCATIONS

MARCH 2013

FIGURE 3-3